

Overview of the LLNL Experimental Effort and Measurement of the Surrogate Reaction $^{92}\text{Zr}(\alpha,\alpha)$

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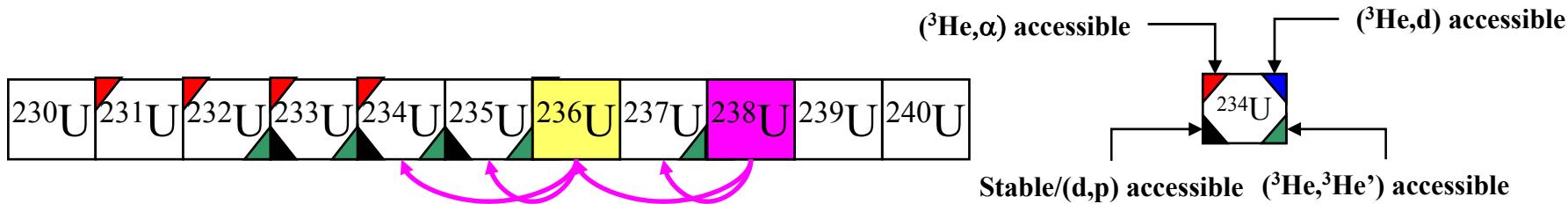
Outline

- The LLNL Experimental Program
- $^{92}\text{Zr}(\alpha, \alpha \dots)$ at Yale
 - Silicon Telescope Array for Reaction Studies (STARS)
 - Experimental Challenges
- Outlook



LLNL Experimental Program

	Neutron-induced Reaction	Surrogate Reaction
Actinide Targets:	$^{235-237}\text{U}(\text{n},\gamma), (\text{n},\text{n}'), (\text{n},2\text{n}), (\text{n},\text{f})$ (4/04) $^{239}\text{Pu}(\text{n},\gamma), (\text{n},\text{n}'), (\text{n},2\text{n}), (\text{n},\text{f})$	e.g. $^{238}\text{U}(\text{p},\text{p}/\text{d}/\text{t})$



Radiochemistry:		
Neutron Monitors	$^{87-88}\text{Y}(\text{n},\gamma), (\text{n},\text{n}'), (\text{n},2\text{n})...$ $^{88-90}\text{Zr}(\text{n},\gamma), (\text{n},\text{n}'), (\text{n},2\text{n})...$ (11/03)	$^{92}\text{Zr}(^3\text{He}, \alpha/^3\text{He})$
Charged-particle Monitors	$^{48}\text{V}(\text{n},\gamma), (\text{n},\text{p}), (\text{n},\text{pn})...$ $^{79,81}\text{Kr}(\text{n},\gamma), (\text{n},\text{p}), (\text{n},\text{pn})...$	e.g. $^{49}\text{Ti}(^3\text{He}, \text{t})$

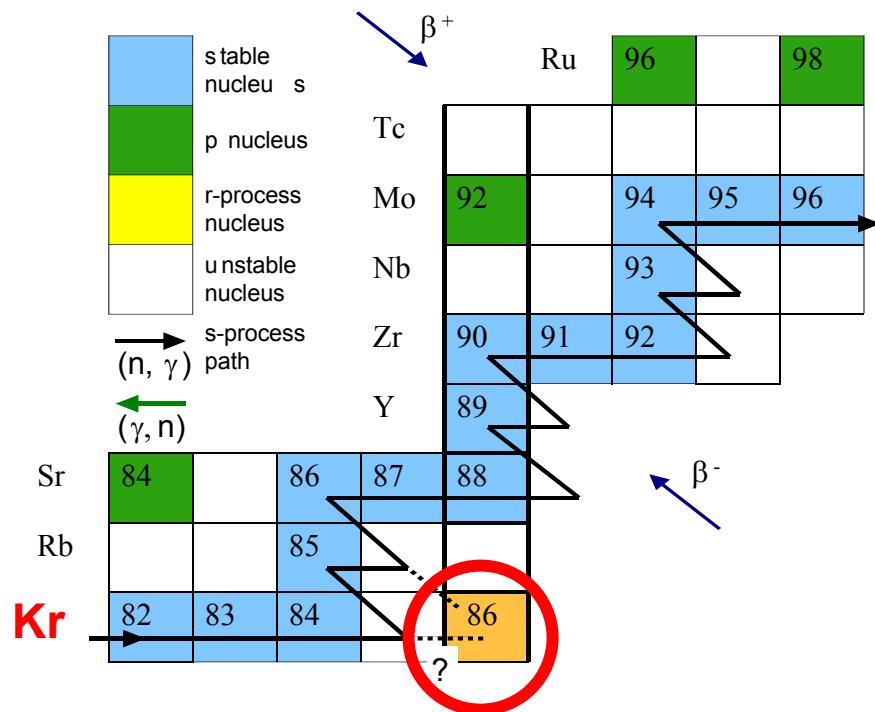


LLNL Experimental Program II

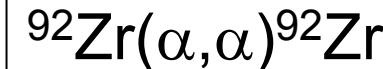
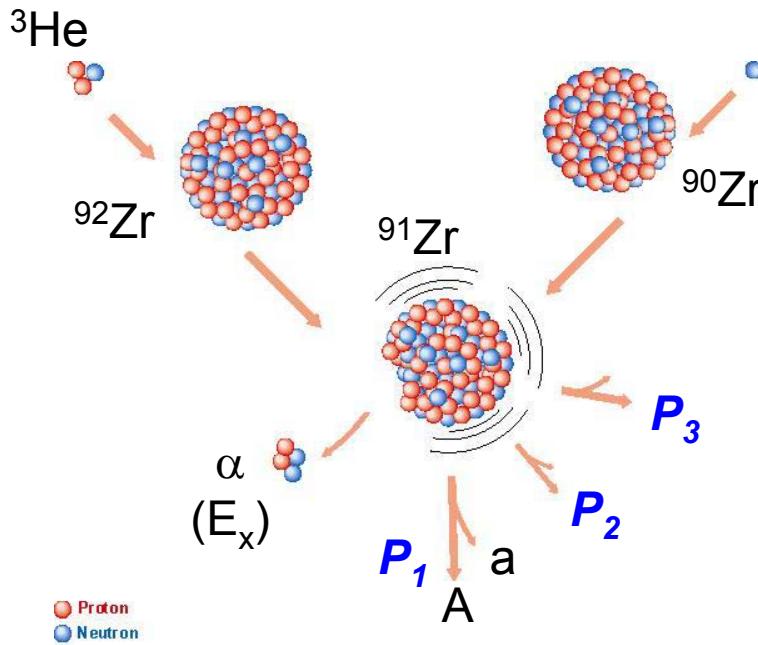
	Neutron-induced Reaction	Surrogate Reaction
Astrophysics r,s,p- processes	$^{85}\text{Kr}(n,\gamma)$ $^{79}\text{Se}(n,\gamma)$	e.g. $^{85}\text{Kr}(\alpha,\alpha)$



- ^{86}Kr is produced in both s- and r-processes.
- ^{85}Kr is an s-process branch-point nucleus.
- $n + ^{85}\text{Kr} \rightarrow ^{86}\text{Kr} + \gamma$



Surrogate Reactions for n+^{90,91}Zr



4-way comparison

1. STAPRE calculation (R. Hoffman)
2. GEANIE data (P. Garrett)
3. Absolute cross sections (Frehaut)
4. Present work

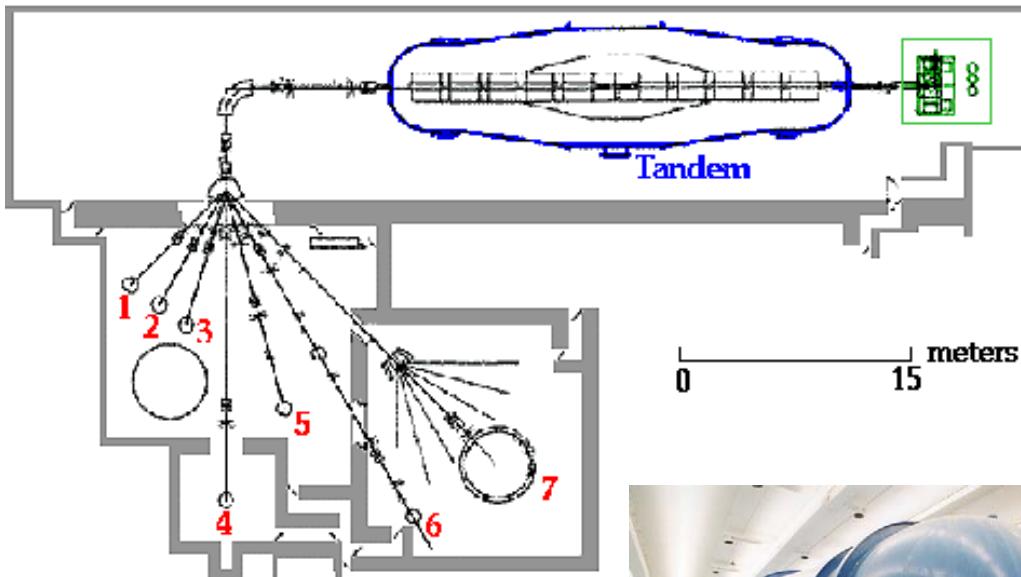
Goal: _____

$$P(E_x) = \frac{I_\gamma(E_x) \varepsilon_{\gamma-p} \tau_{live} (1 + \alpha)}{N_p(E_x)}$$

where I_γ is the γ -ray intensity at E_x , $\varepsilon_{\gamma-p}$ is the γ -p efficiency, τ_{live} is the dead-time correction, α is the conversion coefficient, and N_p is the number of scattered particles detected at E_x .



Wright Nuclear Structure Laboratory



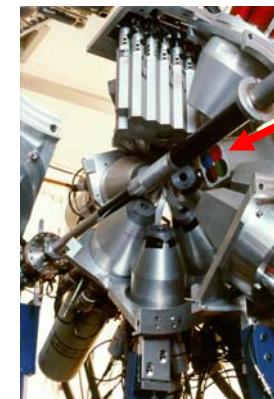
The Yale Tandem



α beam

- 51 MeV
- 8 enA
- diameter \sim 2mm

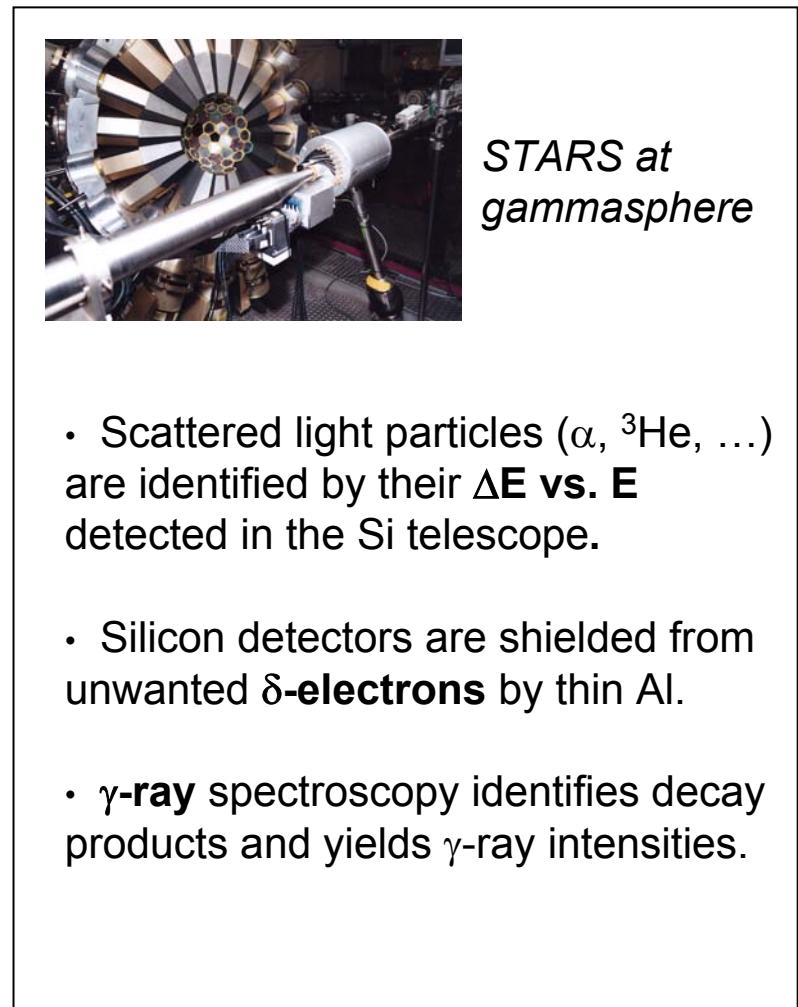
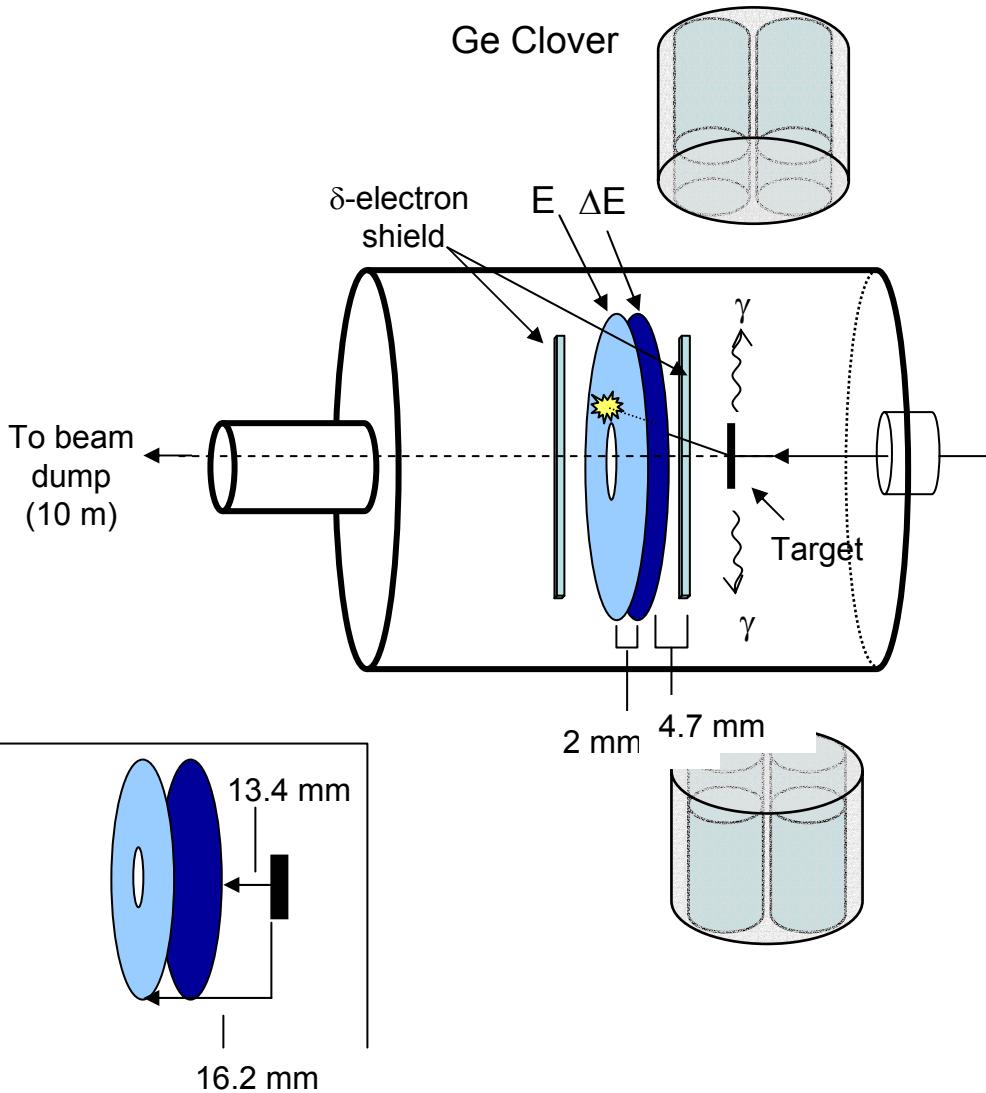
The YRAST ball



Ge Closer

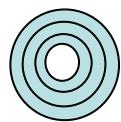


Surrogate Measurement

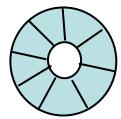


STARS

2 double-sided silicon detectors.



24 Rings- 24 angles (vs. 8 at gamma-sphere)



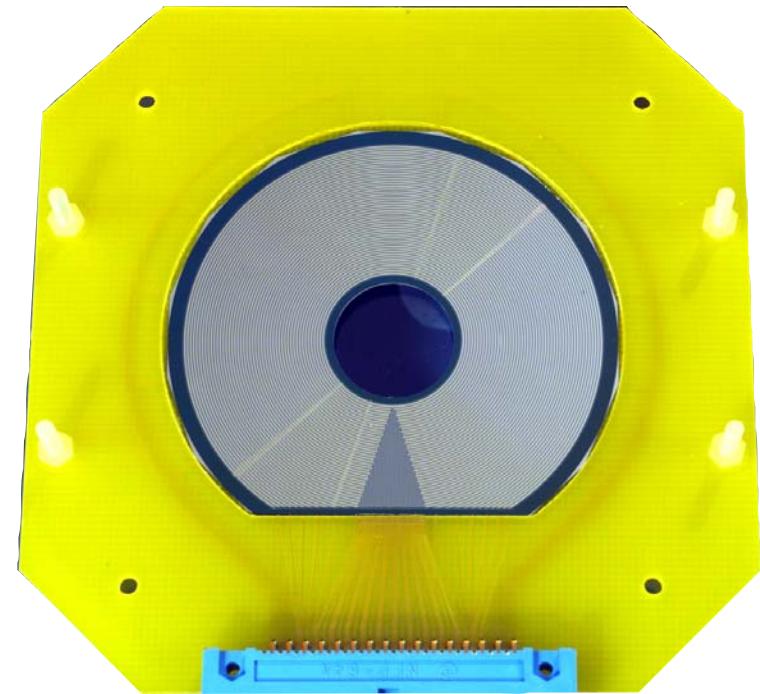
8 Sectors on reverse side- redundancy!

Energy resolution 10-20%

Particle efficiency 20%

Count rate restriction minimal

Thicknesses 100-1000 μm

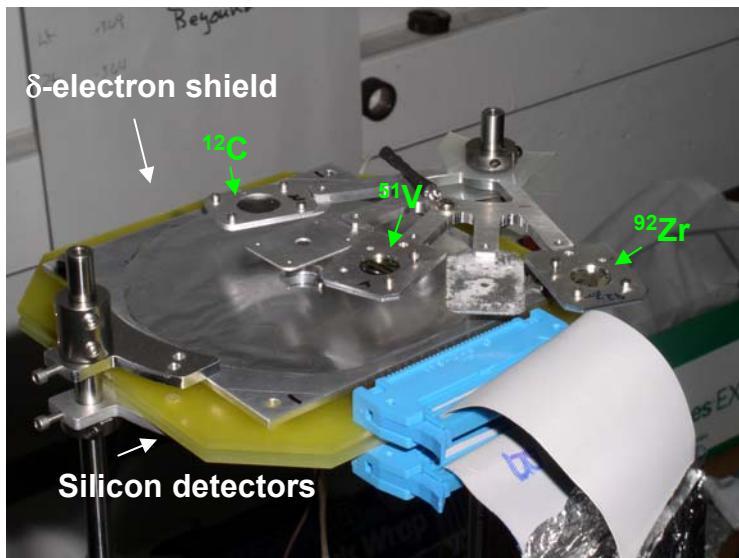


Ring-side of a STARS detector



STARS at Yale

- 5 position target ladder at +300 V
- Detector “Pack”:
 - 0.25 mil Al δ -shield
 - 140 μ m ΔE Si
 - 1000 μ m E Si
 - 5 mil “back shield” at +300 V

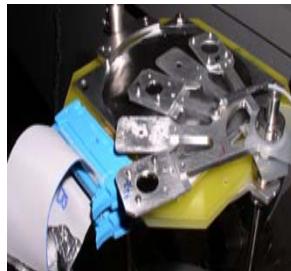


The interior of the STARS chamber.

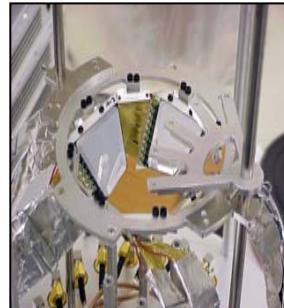


STARS: Yale vs. γ -sphere

$N_{rxn} =$	ε_γ	ε_p	σ_{rxn}	I_{beam} (1/s)	th_{target}	time
Yale	2.7%	20%	...	6×10^{10}
γ -sphere	9.3%	10%	...	2×10^9



STARS at Yale



STARS at γ -sphere
(SIRI)

Assuming the same reaction,
target thickness and time on target:

$$N_{Yale}/N_{GS} = 17$$



Experimental Challenges

1. **Alignment**
 2. **Leakage current** on back detector increases rapidly.
 - Unexpected due to presence of **δ -electron** shield upstream.
 - Added a second shield to downstream side, and applied bias.
 3. **Vacuum** begins to trip intermittently
 - Rear δ -shield sparking
 - Lowered bias on shield from +500 mV to +300 mV, vacuum stabilizes.
-



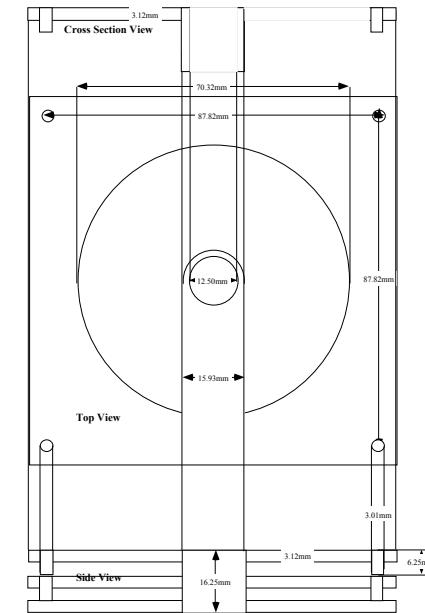
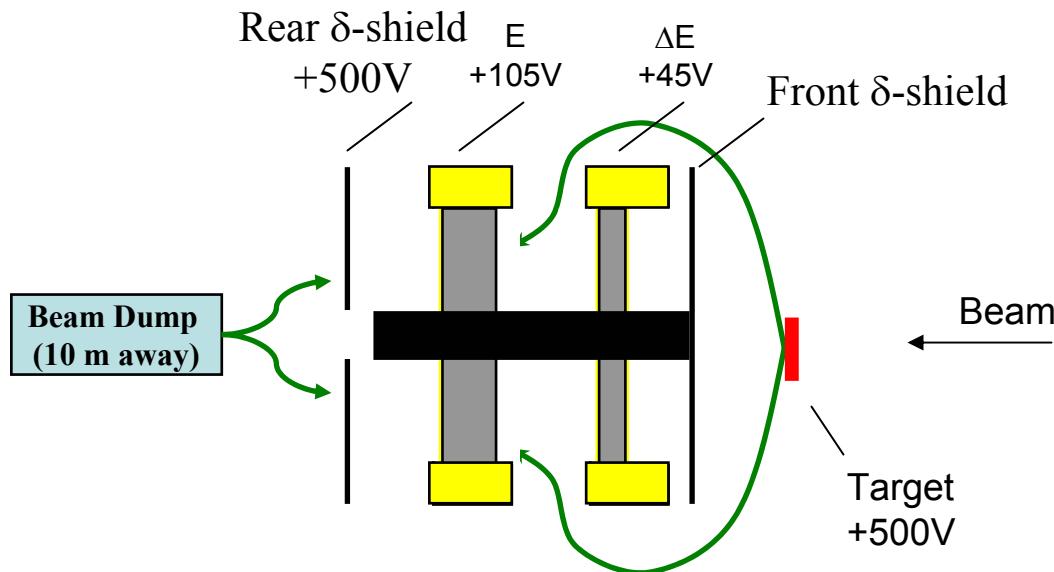
δ -electron shields

Front Shield

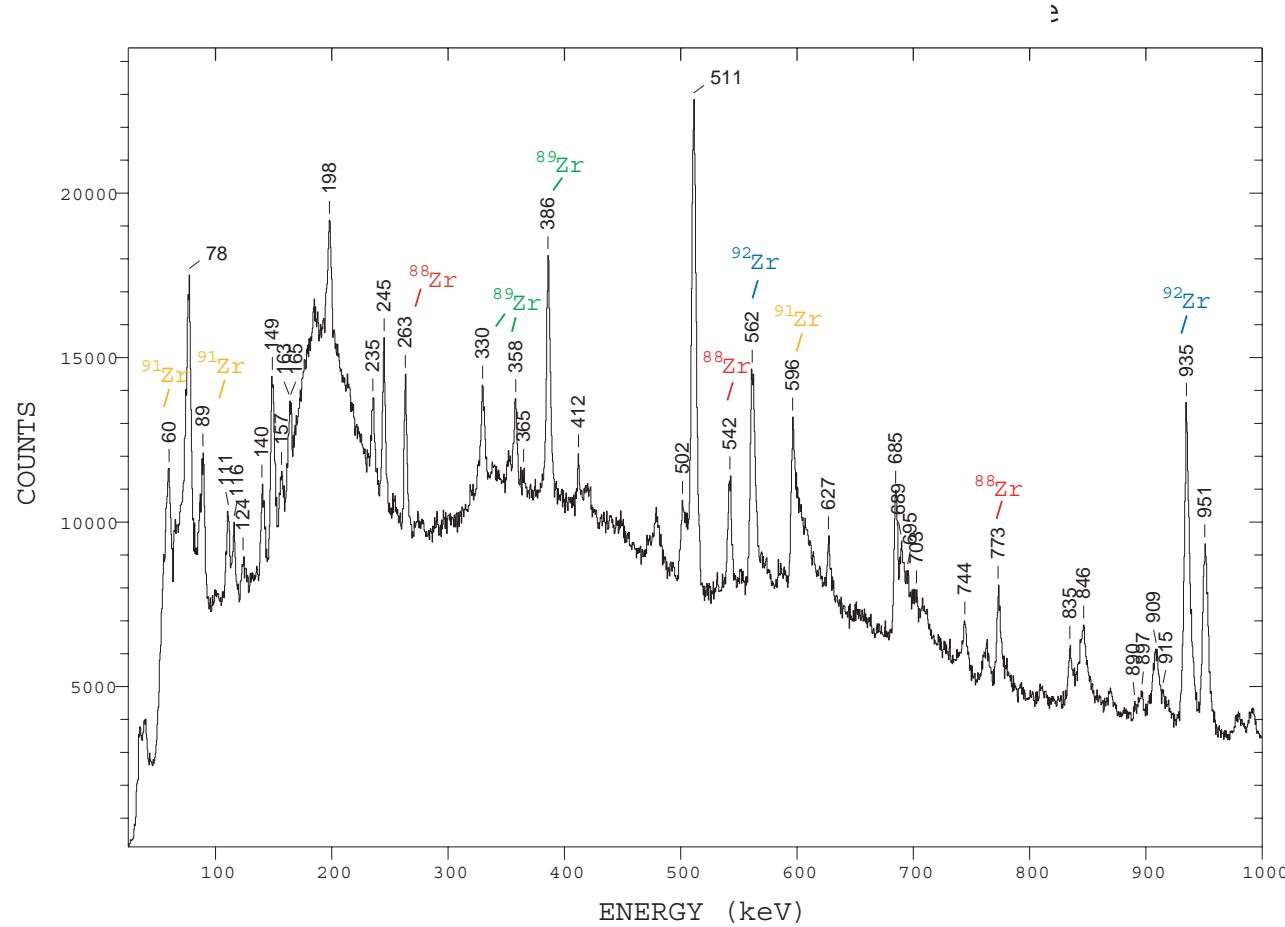
- 0.25 mil Al on a 60 mil Al frame
- 12 mm. OD hole
- Inner cylinder
- Lets through both fission fragments

Back Shield

- Reynold's Wrap
- Bias to +500V then +300V
- No inner cylinder



Surrogate α + ^{92}Zr at Yale



Outlook

- $^{92}\text{Zr}(\alpha,\alpha)^{92}\text{Zr}$ performed 11/03 at Yale.
- STARS detectors undergo in-beam test.
- First look at data promising.
- Analysis underway.
- $^{238}\text{U}(\text{p},\text{p/d/t})$ scheduled for April.

